

CLAIMS

1. A nonreciprocal optical element comprising:
circulator means for routing a first signal from a first port to a second port and a second signal from the second port to a third port, a third signal from the third port to a fourth port and a fourth signal from the fourth port to the first port;
5 first reflective means for reflecting a signal output by the second port back into the second port; and
second reflective means for reflecting a signal output by the fourth port back into the fourth port.

2. The invention of Claim 1 wherein the circulator means includes a circulator.

3. The invention of Claim 1 wherein the reflective means is mirrors.

4. The invention of Claim 1 further including a first polarization rotation element between the second port and the first reflective means.

5. The invention of Claim 4 further including a second polarization rotation element between the fourth port and the second reflective means.

6. The invention of Claim 5 wherein the polarization rotation elements are quarter-wave plates.

7. The invention of Claim 1 further including first means for adjusting transmittance of the signal output by the second port disposed between the second port and the first reflective means.

8. The invention of Claim 7 further including second means for adjusting

transmittance of the signal output by the fourth port disposed between the fourth port and the second reflective means.

9. The invention of Claim 8 wherein the means for adjusting transmittance is filters.

10. The invention of Claim 1 further including means for adjusting the phase of the signal output from the second port.

11. The invention of Claim 10 wherein the means for adjusting the phase includes means for adjusting the position of the first reflective means relative to the second port.

12. The invention of Claim 1 further including means for adjusting the phase of the signal output from the fourth port.

13. The invention of Claim 12 wherein the means for adjusting the phase includes means for adjusting the position of the second reflective means relative to the fourth port.

14. The invention of Claim 1 further including means for effecting spectral control of the signal output from the second port.

15. The invention of Claim 14 wherein the means for effecting spectral control is a spectral filter.

16. The invention of Claim 15 wherein the spectral filter includes a Bragg grating.

17. The invention of Claim 15 wherein the spectral filter includes an

interference filter.

18. The invention of Claim 1 further including means for effecting spectral control of the signal output from the fourth port.

19. The invention of Claim 18 wherein the means for effecting spectral control is a spectral filter.

20. The invention of Claim 19 wherein the spectral filter includes a Bragg grating.

21. The invention of Claim 19 wherein the spectral filter includes an interference filter.

22. A nonreciprocal optical element comprising:

a circulator having first, second, third and fourth ports, the first port being a first input/output port of the nonreciprocal optical element and the third port being a second input/output port of the nonreciprocal optical element;

5 a first mirror disposed to reflect a signal output by the second port back into the second port; and

a second mirror disposed to reflect a signal output by the fourth port back into the fourth port.

23. The invention of Claim 22 further including a first polarization rotation element between the second port and the first mirror.

24. The invention of Claim 23 further including a second polarization rotation element between the fourth port and the second mirror.

25. The invention of Claim 24 wherein the polarization rotation elements are

quarter-wave plates.

26. The invention of Claim 22 further including first means for adjusting transmittance of the signal output by the second port disposed between the second port and the first mirror.

27. The invention of Claim 26 further including second means for adjusting transmittance of the signal output by the fourth port disposed between the fourth port and the second mirror.

28. The invention of Claim 27 wherein the means for adjusting transmittance is filters.

29. The invention of Claim 22 further including means for adjusting the phase of the signal output from the second port.

30. The invention of Claim 22 further including means for adjusting the phase of the signal output from the fourth port.

31. The invention of Claim 22 further including means for effecting spectral control of the signal output from the second port.

32. The invention of Claim 31 wherein the means for effecting spectral control is a spectral filter.

33. The invention of Claim 32 wherein the spectral filter includes a Bragg grating.

34. The invention of Claim 32 wherein the spectral filter includes an interference filter.

35. The invention of Claim 22 further including means for effecting spectral control of the signal output from the fourth port.

36. The invention of Claim 35 wherein the means for effecting spectral control is a spectral filter.

37. The invention of Claim 36 wherein the spectral filter includes a Bragg grating.

38. The invention of Claim 36 wherein the spectral filter includes an interference filter.

39. A method for transmitting first and second signals in opposite directions through a device and effecting independent control thereof including the steps of:

routing a first signal from a first port to a second port and a second signal from the second port to a third port, a third signal from the third port to a fourth port and a
5 fourth signal from the fourth port to the first port;
reflecting a signal output by the second port back into the second port; and
reflecting a signal output by the fourth port back into the fourth port.